What is the relationship between the intake of animal protein products and type 2 diabetes?

Conclusion

Limited inconsistent evidence from prospective cohort studies suggests that intake of animal protein products, mainly processed meat, may have a link to type 2 diabetes.

Grade: Limited

Overall strength of the available supporting evidence: Strong; Moderate; Limited; Expert Opinion Only; Grade not assignable For additional information regarding how to interpret grades click here.

Evidence Summary Overview

This review included seven articles (Djousse, 2009; Fung, 2004; Halton, 2008; Schulze, 2003; Song, 2004; van Dam, 2002; Vang, 2008) published since 2000 representing prospective cohorts from the US. In the three studies examining total animal protein intake, two reported a positive association with type 2 diabetes (T2D) (Song, 2004; Vang, 2008) and one reported no association (Halton, 2008). All five studies that reported on the relationship between the intake of processed meats and T2D reported a positive association (Fung, 2004; Schulze, 2003; Song, 2004; van Dam, 2002; Vang, 2008). Inconsistent findings were reported related to the intake of red meat and poultry. Some of the reported risk found in these studies may be attributed to obesity or weight gain, but controlling for this supported meat intake as an important risk factor for diabetes. Other dietary factors, such cereal fiber, fat and total calories, also are strong in this relationship and the association between T2D and animal protein is attenuated when there is adjustment for these factors.

Evidence Summary Paragraphs

Djousse et al, 2009 (positive quality) prospectively examined the association between egg consumption and incident T2D among men and women in the US. Participants were 20,703 men (age 53.5±9.4 years) from the Physician's Health Study (PHS) I and 36,295 women (age 54.5±7 years) from the Women's Health Study (WHS).Type 2 diabetes was ascertained by self-report on annual follow-up questionnaires for both men and women. Among participants in the WHS, self-reporting was validated using telephone interviews, supplemental questionnaires or review of medical records. Information on egg consumption in the past year from the PHS and WHS was self-reported. For men, the information was obtained using a semi-quantitative food-frequency questionnaire (FFQ) at baseline and at 24, 48, 72, 96 and 120 months. For women, the information was self-reported using a 131-item validated FFQ at baseline. During mean follow-up of 20.0 years in men and 11.7 years in women, 1,921 men and 2,112 women developed T2D. Compared with no egg consumption, multivariable adjusted hazard ratios (HRs) for T2D were 1.09 (95% CI: 0.87, 1.37), 1.09 (0.88, 1.34), 1.18 (0.95, 1.45), 1.46 (1.14, 1.86) and 1.58 (1.25, 2.01) for consumption of less than one, one, two to four, five to six and at least seven eggs per week, respectively, in men (P for trend<0.0001). Corresponding multivariable HRs for women were 1.06 (95% CI: 0.92, 1.22), 0.97 (0.83, 1.12), 1.19 (1.03, 1.38), 1.18 (0.88, 1.58) and 1.77 (1.28, 2.43), respectively (P for trend<0.0001). The authors concluded that daily consumption of at least one egg is associated with an increased risk of T2D in men and women, independently of traditional risk factors for T2D.

Fung et al, 2004 (positive quality) prospectively examined the association between major dietary patterns and the risk of T2D among women in the US. Participants were 69,554 women (age 38 to 63 years) from the Nurses' Health Study cohort. Type 2 diabetes was ascertained by self-report on biennial questionnaires. Women reporting a diagnosis of diabetes were sent supplementary questionnaires asking about symptoms, diagnostic tests and treatment to confirm the diagnosis. Dietary intake information was collected by FFQs designed to assess average food intake over the previous year. Information from the FFQs administered in 1984, 1986, 1990 and 1994 were used in this analysis. Factor analysis identified two major dietary patterns: "Prudent" and "Western." During 14 years of follow-up, 2,699 incident cases of T2D were identified. After adjusting for potential confounders, the relative risk (RR) for diabetes was 1.49 (95% CI: 1.26, 1.76, P for trend<0.001) when comparing the highest to lowest quintiles of the Western pattern. Positive associations were observed between T2D and red meat and other processed meats. Intake of total processed meats showed the strongest positive association, with an RR of 1.60 (95% CI: 1.39, 1.83; P for trend, <0.001) between the top and bottom quintile of intake. When meat products were analyzed as a continuous variable, the RR for diabetes for every one-serving increase in intake was 1.26 (95% CI: 1.21, 1.42) for red meat, 1.38 (95% CI: 1.23, 1.56) for total processed meats, 1.73 (95% CI: 1.39, 2.16) for bacon, 1.49 (95% CI: 1.04, 2.11) for hot dogs and 1.43 (95% CI: 1.22, 1.69) for processed meats. The authors concluded that the Western dietary pattern, especially a diet higher in processed meats, may increase the risk of T2D in women.

Halton et al, 2008 (positive quality) prospectively examined the association between a low-carbohydrate diet and the risk of T2D among females in the US. Additional analyses examined the relationship between macronutrient intake, including animal protein and T2D. Participants were 85,059 women (age 30 to 55 years, 98% white) from the Nurses' Health Study cohort. Type 2 diabetes was ascertained by self-report on biennial questionnaires. If a participant reported a diagnosis of diabetes, a supplementary questionnaire was mailed regarding symptoms, diagnostic testing and treatment to confirm the diagnosis. Diet over the previous year was assessed by means of a semi-quantitative FFQ in 1980, 1984, 1986, 1990, 1994 and 1998. During 20 years of follow-up, 4,670 cases of T2D were documented. Animal protein intake was positively associated with T2D risk, with an age adjusted RR of 1.74 (95% CI: 1.51, 2.01; P for trend<0.0001) between extreme deciles. However, this relationship was attenuated when further adjusted for non-dietary factors plus cereal fiber, saturated fat, polyunsaturated fat, monounsaturated fat, trans fat, vegetable protein and total calories (multivariate RR=1.01; 95% CI: 0.87, 1.17; P for trend=0.55). The authors concluded that animal protein intakes were not associated with risk of T2D in women.

Schulze et al, 2003 (positive quality) prospectively investigated the association between processed and other meat intake and incidence of T2D in a large cohort of young and middle-aged women in the US. Participants were 91,246 women (age 24 to 44 years) from the Nurses' Health Study II. Type 2 diabetes was ascertained by self-report on biennial questionnaires. Women reporting a new diagnosis of diabetes were sent supplementary questionnaires asking about diagnosis, treatment and symptoms to confirm diagnosis. Food consumption over the previous year was assessed using a 133-item semi-quantitative FFQ at baseline (1991). During eight years of follow-up, 741 incident cases of T2D were confirmed. The multivariate RRs across frequencies of processed meat consumption (less than one per week, one per week, two to four per week and at least five per week) were 1.00, 1.16 (95% CI: 0.97, 1.39), 1.44 (95% CI: 1.14, 1.82) and 1.91 (95% CI: 1.42-2.57) (P for trend<0.001). Further adjustment for intakes of magnesium, cereal fiber, glycemic index and caffeine or for a Western dietary pattern did not appreciably change the results and associations remained strong after further adjustment for fatty acid and cholesterol intake. The multivariate RRs across categories of total red meat consumption (less than one per week, one per week, two to four per week and at least five per week) were 1.00, 1.19 (95% CI: 0.79, 1.80), 1.38 (95% CI: 0.91, 2.09)

and 1.58 (95% CI: 1.03, 2.42) (P for trend=0.003). Total red meat intake was associated with only a modest and non-significant (NS) increase of diabetes risk (RR for extreme categories: 1.44; 95% CI: 0.92, 2.24) in multivariate analysis after additional adjustment for magnesium, glycemic index, cereal fiber and caffeine. Frequent consumption of bacon, hot dogs, sausage and hamburgers was each associated with an increased risk of diabetes. More frequent poultry intake was associated with a moderately decreased risk of diabetes. The multivariate-adjusted RRs across categories of poultry intake (no more than one per week, two to four per week and at least five per week) were 1.00, 0.87 (95% CI: 0.74, 1.02) and 0.78 (95% CI: 0.62, 0.98) (P for trend=0.017). Further adjustment for nutrient intake or the "Prudent" dietary pattern did not materially change this result. The authors concluded that diets high in processed meats could increase the risk for developing T2D in young and middle-aged women.

Song et al, 2004 (positive quality) prospectively assessed the associations between red meat and processed meat consumption and incidence of T2D in US women. Participants were 37,309 women (age ≥45 years) from the Women's Health Study. Type 2 diabetes was ascertained by self-report on annual questionnaires with confirmation in a sub-set of the sample. Dietary intake was assessed with a 131-item semi-quantitative FFQ at baseline (1993). Over an average of 8.8 years, 1,558 incident cases of T2D were identified. Comparing women in extreme quintiles, the multivariate-adjusted RR of T2D were 1.28 for red meat (95% CI: 1.07, 1.53; P for trend<0.001) and 1.23 for processed meat intake (95% CI: 1.05, 1.45; P for trend=0.001). Furthermore, the significantly increased diabetes risk appeared to be most pronounced for frequent consumption of total processed meat (RR=1.43; 95% CI: 1.17, 1.75 for at least five per week vs. less than one per month; P for trend<0.001) and two major sub-types, which were bacon (RR=1.21; 95% CI: 1.06, 1.39 for at least two per week vs. less than one per week; P for trend=0.004) and hot dogs (RR=1.28; 95% CI: 1.09, 1.50 for at least two per week vs. less than one per week; P for trend=0.003). These results remained significant after further adjustment for intakes of dietary fiber, magnesium, glycemic load and total fat. Multivariate adjusted RR comparing extreme quintiles of animal protein intake was 1.44 (95% CI: 1.16, 1.78; P for trend=0.001). The authors concluded that higher consumption of total red meat, especially various processed meats, may increase risk of developing T2D in women.

van Dam et al, 2002 (positive quality) prospectively examined the association between risk of T2D and trans-fat, specific polyunsaturated fats and meats in US men. Participants were 42,504 men (age 40-75 years) from the Health Professionals Follow-Up Study. Diabetes was assessed by questionnaire every two years from baseline (1986) through 1998. A supplementary questionnaire on symptoms, diagnostic tests and medication was mailed to all men to confirm diagnosis. Diet was assessed by a semi-quantitative FFQ in 1986 and again in 1990 and 1994 to update dietary information. During 12 years of follow-up, 1,321 incident cases of T2D were identified. Frequent consumption of processed meat was associated with a higher risk for T2D (RR=1.46; 95% CI: 1.14, 1.86 for at least five per week vs. less than one per month; P for trend<0.0001). Consumption of unprocessed red meat (RR=1.05; 95% CI: 0.85, 1.30 for highest vs. lowest quintile) and of poultry (RR=1.12; 95% CI: 0.95, 1.32) was not substantially associated with risk for T2D. Of the eight questionnaire items on meat and poultry consumption, only consumption of the three processed meat items: Bacon (RR=1.33; 95% CI: 1.11, 1.58; P for trend=0.0002), hot dogs (RR=1.26; 95% CI: 1.00, 1.60; P for trend=0.03) and other processed meats (RR=1.18; 95% CI: 0.99, 1.41; P for trend=0.01) plus hamburgers (RR=1.27; 95% CI: 0.99, 1.62) were appreciably associated with diabetes risk. Consumption of beef, lamb or pork as a main dish or a mixed dish; or chicken or turkey with or without skin was not substantially associated with risk of T2D. The authors concluded that frequent consumption of processed meats may increase risk of T2D in men.

Vang et al, 2008 (positive quality) prospectively examined the relationship between total animal product consumption, specific animal product consumption (red meat, poultry, fish, processed

meats, eggs, milk, cheese) and diabetes occurrence. Participants were 8,401 adults (age 45 to 88 years) from the Adventist Mortality Study and the Adventist Health Study in the US. Participants completed questionnaires in 1960 and 1976. Incident diabetes cases were based on disease history data from the 1976 questionnaire. Dietary intake was assessed in 1960 and 1976 with questionnaires containing food frequency questions. Specific animal product consumption included: Red meat/poultry, eggs and processed meats (salted fish and frankfurters). During the 17-year follow-up, 543 incident diabetes cases were identified. Participants who were weekly consumers of all meats (red meat, poultry, fish) were 29% more likely relative to zero meat intake to develop diabetes (OR=1.29; 95% CI: 1.08, 1.55). An increase in risk for weekly intake of red meat and poultry (OR=1.27; 95% CI: 1.06, 1.53), but not for weekly intake of fish (OR=1.12; 95% CI: 0.88, 1.44) was observed. Subjects who consumed any processed meats (salted fish and frankfurters) were 38% more likely to develop diabetes than those who did not consume any processed meats (OR=1.38; 95% CI: 1.05, 1.82). Long-term adherence (over the 17-year interval) to a diet that included at least weekly meat intake was associated with a 74% increase in odds of diabetes relative to long-term adherence to a vegetarian diet (zero meat intake) (OR=1.74; 95% CI: 1.36, 2.22). Further analyses indicated that some of this risk may be attributable toobesity or weight gain; both of which were strong risk factors in this cohort. Even after control for weight and weight change, weekly meat intake remained an important risk factor (OR=1.38; 95% CI 1.06-1.08) for diabetes. The authors concluded that meat intake, particularly processed meats, may be a dietary risk factor for diabetes.

⊡ View table in new window

Author, Year, Study Design, Class, Rating	Study Name/Location	Total Meat Association (Pos, Neg, None)	Red Meat Association (Pos, Neg, None)	Processed Meat Association (Pos, Neg, None)	Poultry Association (Pos, Neg, None)
Djousse et al 2009 Study Design: Prospective Cohort study Class: B Rating: ⊕	Physician's Health Study I and Women's Health Study. Location: US.	Not examined.	Not examined.	Not examined.	Eggs: (+) for men and women.
Fung et al 2004 Study Design: Prospective cohort study Class: B	Nurses' Health Study. Location: US.	Not examined.	Red meat: (+).	Total: (+) Bacon; hot dogs; other processed meats: (+).	Not examined.

Rating: ●					
Halton TL, Liu S et al, 2008 Study Design: Prospective cohort Class: B Rating: ●	Nurses' Health Study. Location: US.	Animal protein: Ø.	Not examined.	Not examined.	Not examined.
Schulze et al 2003 Study Design: Prospective cohort study Class: B Rating: ●	Nurses' Health Study II. Location: US.	Not examined.	Total: Ø. Hamburgers: (+).	Total: (+). Bacon; hot dogs; sausage: (+).	Poultry: (-).
Song Y, Manson JE et al, 2004 Study Design: Prospective cohort study Class: B Rating: ●	Women's Health Study. Location: US.	Animal protein: (+).	Total: (+).	Total: (+). Bacon; hot dogs: (+).	Not examined.
van Dam RM, Willett WC et al, 2002 Study Design: Prospective cohort Class: B Rating: ●	Health Professionals Follow-Up Study. Location: US.	Not examined.	Unprocessed red meat: Ø. Hamburgers: (+). Beef, pork, or lamb as main or mixed dish: Ø.	Total: (+). Bacon; hot dogs; other processed meats: (+).	Poultry: Ø.

Vang A, Singh PN et al, 2008 Study Design: Prospective cohort Class: B Rating: ⊕	Adventist Morality and Adventist Health Studies. Location: US.	Total (red meat, poultry, and fish): (+)	Red meat and poultry: (+).	"Salted fish and frankfurters": (+).	Red meat and poultry: (+).

Research Design and Implementation Rating Summary

For a summary of the Research Design and Implementation Rating results, click here.

Worksheets

📋 Djousse L, Gaziano JM, Buring JE, Lee. I. Egg Consumption and Risk fo Type 2 Diabetes in Men and Women. *Diabetes Care* 2009;32:295-300.

📋 Fung TT, Schulze M, Manson JE, Willett WC, Hu FB. Dietary patterns, meat intake, and the risk of type 2 diabetes in women. *Arch Intern Med.* 2004;164(20):2235-2240.

📋 Halton TL, Liu S, Manson JE, Hu FB. Low-carbohydrate-diet score and risk of type 2 diabetes in women. *Am J Clin Nutr.* 2008; 87 (2): 339-346.

📋 Schulze MB, Manson JE, Willett WC, Hu FB. Processed meat intake and incidence of Type 2 diabetes in younger and middle-aged women. *Diabetologia.* 2003;46(11):1465-1473.

📋 Song Y, Manson JE, Buring JE, Liu S. A prospective study of red meat consumption and type 2 diabetes in middle-aged and elderly women: the Women's Health Study. *Diabetes Care.* 2004; 27(9): 2,108-2,115.

📋 van Dam RM, Willett WC, Rimm EB, Stampfer MJ, Hu FB. Dietary fat and meat intake in relation to risk of type 2 diabetes in men. *Diabetes Care.* 2002 Mar; 25 (3): 417-424.

📋 Vang A, Singh PN, Lee JW, Haddad EH, Brinegar CH. Meats, processed meats, obesity, weight gain and occurrence of diabetes among adults: Findings from Adventist Health Studies. *Ann Nutr Metab* 2008; 52 (2): 96-104.